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An analysis of the Greek photovoltaic market

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Abstract

The number of photovoltaic applications has increased slightly over the last 10 years in Greece, with a forecasted 40% increase in the annual rate of sales over the next few years, a target similar to the rest of the EU Member States. This article: (i) presents an analysis of the current situation on the photovoltaic market in Greece and attempts to segment this market; (ii) investigates the existing incentives policy, as well as the crucial barriers for the wide dissemination of the photovoltaic applications, and (iii) records the market actors' aspects and predictions for the future. Furthermore, in order to supply essential information for business development, the current investment and legislative framework is presented.

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1. Introduction

During the last decade a continuously increasing interest in renewable energy sources (RES), was noted in Greece. This was a combined effect of (i) the favourable legal and financial measures that were implemented, (ii) the rich potential existing in the country and (iii) the rising environmental awareness.

In 2000 RES contributed a total of 1.403 ktoe to the Greek energy system. This corresponds to 5% of the Greek Total Primary Energy Supply (TPES), which was about 28.1 Mtoe. Electricity generation from RES (RESe) was 4.145 GWh in 2000

with a total installed capacity of 3.334 MW. The major contribution to the electricity generation was from hydros (3.693 GWh), while photovoltaic (PV) contributed only a small amount, mainly in installations that are not grid connected. Solar energy applications are almost exclusively used for water heating (Tables 1 and 2) [7].

Greece is a country with an extremely high potential for solar and especially for PV applications, mainly due to:

- the high insolation all year round (among the highest in Europe)
- the electricity needs in the islands are mostly covered by diesel/heavy oil generation units, thus resulting in high operation costs and environmental pollution
- the significant tourism activity during summer (environmental burdens in some islands increase by more than 100%), thus offering significant seasonal correlation between energy demand and PV power generation.

However the PV market is not adequately developed compared with other EU markets. In order to create more favorable conditions, nowadays a positive legislative and financing framework has been formulated (Operational Programme for Competitiveness—OPC, Operational Programme for Energy—OPE, deregulation of the energy market, new development law, etc).

This Greek PV market analysis aims:

- to identify the market potential of the PV technologies in the Greek market
- to depict the current situation in Greece and the market potential
- to assess the existing barriers for the wide dissemination of PV systems

Table 1
Energy produced from RES (2000)

Source	ktoe
Biomass	946
Wind	38.8
Small hydro (<10 MW)	14.28
Large hydro[a] (>10 MW)	303.5
PV[b]	0.024
Solar heat	99
Geothermal heat[c]	1.61
Total	1.403

[a] Production through pumping, 35.97 ktoe is excluded.
[b] Grid connected and autonomous island systems (non-connected systems for electricity supply).
[c] Sites with official permits.

Table 2
Current status of renewable energy technologies in Greece (2000)

Technology	Status				Current utilization and capacity	
	C[a]	D[a]	Planned	No	Output (ktoe)	Capacity (MW)
Wood	X				702	N/A
CHP with biomass	X				0.8	2.1 MW_{th} 0.5 MW_e
District heating with biomass	X				0	1.4 MW_{th}
Wood, Vegetal waste in industry	X				242	510
Biogas from agrofood and farm slurries	X				0.3	2.1 MW_{th}
Landfill gas	X				0	0.240 MW_e
Sludge/sewage gas	X				1.7	2.2 MW_{th} 0.359 MW_e
Municipal waste			X			10 MW_{th} 7.4 MW_e
Bio-fuels			X			
Geothermal electricity				X		
Geothermal heat	X				1.61	29 MW_{th}
Solar thermal				X		
Solar heat	X				99	2.94×10^6 m^2
Hydro (>10MW)	X				303.5	3.052
Small Hydro(1–10MW)	X				12.06	42
Small Hydro (< 1 MW)	X				2.22	13.6
Wind	X				38.8	226
PV[b]	X				0.021	332 kWp

[a] C: commercial, D: demonstration.
[b] Grid connected and non-connected systems in islands (does not include small scale isolated panels).

2. Policy framework

2.1. Laws

The basic law governing RESe is Law 2773/99. This law has incorporated the majority of provisions of the earlier Law 2244/94, which was devoted entirely to RESe matters. The key provisions of Law 2773/99 are:

- The Greek Transmission System Operator (HTSO) is obligated to grant priority access to RESe installations up to 50 MW_{el}.
- The HTSO is obligated to enter into a 10-yr contract (Power Purchase Agreement) with the RESe producer, for the purchase of his electricity. The contract always includes a renewal option.
- The RESe production of an independent power producer, or the surplus electricity production of a RES autoproducer, is sold to the HTSO at a pre-

determined buy-back rate, which is a fixed percentage of the corresponding consumer electricity rate.

- The current RESe tariff system distinguishes between 'autoproducers', i.e. producers consuming part of their RESe production themselves and selling the surplus to the grid, and 'independent power producers', i.e. producers selling their entire RESe production to the grid. The buy-back rates for both cases are differentiated as follows:

  (a) For autoproducers, the buy-back rate is set at 70% of the utility's domestic consumer tariff, for RESe produced and sold in the non-interconnected Greek islands, and at 70% of the utility's consumer tariff corresponding to the actual grid-connection voltage of the RES installation (be it low-, mid- or high-voltage), for RESe produced and sold in the Greek mainland.
  (b) For independent power producers, the buy-back rate is set at 90% of the utility's domestic consumer tariff (in the non-interconnected Greek islands), and at 90% of the utility's mid-voltage (commercial) consumer tariff (in the Greek mainland).

- Every RESe producer is subject to a special annual fee equal to 2% of the producer's electricity sales to the grid. This charge is collected by the HTSO and is given to the local authority, within the area of which the RESe generation unit operate, for the purpose of realizing local development projects.

At today's (2003) electricity consumer prices in Greece, an independent RESe producer is paid 0.063 €/kWh in the Greek mainland and 0.078 €/kWh in the non-interconnected islands. Law 2773/99 instituted a new license, the so-called electricity generation license, which is now the first license required to be obtained by any electricity-producing station, conventional or RES-based, in a long planning/licensing procedure that also includes preliminary environmental assessment, land-use permit, approval of environmental terms and conditions, installation license, operation license, etc. (see below).

Law 2941/01 supplemented Law 2773/99 with certain important provisions including: (a) the definition of the general terms and conditions, under which it is allowed to install RES stations in forests and forestry lands, and (b) the characterization of all RES projects as projects of public utility status, which give them the same rights and privileges in land expropriation procedures as those given to public works, independently of the legal status of the RES project owner (being private or public). Laws 2244/94, 2773/99 and 2941/01 on RES are supplemented by a number of Ministerial Decrees.

Finally, it is also important to mention here the legally binding EU Directive 2001/77/EC on RESe and its indicative target for Greece, i.e. 20.1% coverage of the country's total electricity demand by RES, until 2010. This target corresponds to about 2500 MW_{el} of RES installations, an 8-fold increase over the currently installed RES capacity of about 320 MW_{el}.

2.2. Financial instruments

There are two main financial-support instruments that provide substantial public subsidies to RES investment projects (among others): (a) the so-called 'National Development Law' (Law 2601/98, currently under revision), and (b) the Greek OPC, one of the 11 National and the 13 Regional Operational Programmes, in which the 3rd Community Support Framework (CSF III; 2000–2006) for Greece is divided [4].

2.2.1. National Development Law 2601/98

This is a financial instrument umbrella, covering all private investments in Greece. It has a strong regional character, since regions with high unemployment rates and low incomes per capita receive the highest investment subsidies from the State.

Investments in RESe installations have a special status under Law 2601/98, similar to the one bestowed to other selected categories of investments, such as investments in high technology, environmental protection, etc. More specifically:

- 40% public subsidy (grant) on the total eligible RES investment cost +40% subsidy on the interest of loans obtained for the purpose of financing the RES investment
- Alternatively, 40% subsidy on the loan interest +100% tax deduction on the RES investment cost
- Level of subsidy (40%) is independent of the RES technology and the geographical region
- Required own capital: 40% (min) of the total investment cost
- Minimum investment cost required: 176 k€
- Maximum subsidy granted: 14.7 M€
- Maximum investment cost subsidized: 36.7 M€

Law 2601/98 does not have any total budget cup, thus there is (theoretically) no limit in the number and budget of proposals that can be funded.

It should be noted that Law 2601/98 is currently under revision by the Ministry of National Economy and the new Law should become operational before the end of 2003. Preliminary information from the Ministry indicates that direct subsidies to investments will decrease, in favour of increased tax deductions. RES are expected to retain their special investment status, leading to increased subsidy rates, compared to most other types of investments.

2.2.2. National operational programme for competitiveness/measure 2.1

The Measure 2.1 of Subprogramme 2 of the National OPC/CSF III (2000–2006) is devoted entirely to providing State support (grants) to private investments in: (a) RES, (b) rational use of energy (RUE) and (c) small-scale (<50 MW_e) cogeneration (CHP). The total budget of Measure 2.1, for the 2000–2006 period of CSF III, is 1.07 G€, of which 35.6% is the public subsidy available to RES/RUE/CHP

investments; about 2/3 of the total available subsidy (~260 M€) is foreseen to be awarded specifically to RES investment projects.

The main provisions of Measure 2.1 of OPC, concerning public support of RES investments, are as follows, in particular for PV:

- Public subsidy (grant) on the total eligible PV investment cost: 40–50%
- Required own capital: 30% (min) of the total investment cost
- Minimum investment cost required: 44 k€
- Maximum investment cost subsidized: 44 M€

It should be mentioned that a RES investment–subsidy programme also existed in the 2nd Community Support Framework (CSF II; 1994–1999) for Greece. This CSF II programme granted cumulatively about 92 M€ of public subsidies to 78 RES investment projects, having a total budget of about 213 M€ (i.e. mean subsidy rate ~43%) and a total installed capacity of 161 MW_e + 102 MW_{th}. This programme was very instrumental in generating substantial RES activity and in materializing a large number of commercial-scale RES projects in Greece, particularly in the period 1997–2000, as indicated in Table 5.

2.2.3. *Tax and other fiscal incentives*

The one legislative provision that was in effect until recently, in the area of tax incentives for domestic RES installations, was incorporated in Law 2364/95. This law, although dealing primarily with the importation, transmission, distribution and sales of natural gas in Greece, contained an important provision regarding the purchase and installation of domestic RES appliances. Up to 75% of the total cost for the purchase and installation of domestic RES appliances and systems could be deducted from the taxable income of natural persons. Such appliances and systems were deemed to include installations for the common use of the occupants of apartment buildings, in which case the deduction was calculated on the basis of the co-ownership percentage of each owner. For legal persons and companies, 75% of the total expenditure for the purchase and installation of the aforementioned appliances or systems was deductible from the total profit established by the application of the tax coefficient or the objective criteria.

Furthermore, a separate Presidential Decree had been planned, entitled 'Incentives for energy savings'. According to this Decree, an integrated set of financial, administrative and other incentives is to be instituted for domestic applications of techniques and systems, including RES that demonstrably contribute to energy savings in buildings. These planned incentives are outlined below:

(a) All expenses related to the purchase and installation of RES systems and materials in existing buildings can be deducted from the taxable income of owners/possessors/usufructuaries, up to a certain percent which will be defined, according to a specific set of criteria.
(b) Owners of existing or new buildings (domestic/commercial/tertiary) who, within a period of six years from the date of enactment of the above Presidential Decree, install RES exploitation systems in their buildings, for space heat-

ing and/or cooling, hot water production or lighting, demonstrably meeting at least 30% of their energy needs with RES, will be entitled to receive certain subsidies or attractive, low-interest loans from State or private banks, in order to cover their RES-related costs.

(c) In case the building owner opts for the low-interest loan, he will not be eligible for the income tax deduction of point (a) above.

(d) In regions with autonomous electricity networks (for example, in islands), or in regions of the interconnected system where the PPC is unable to cover the peak load, PPC can provide relevant subsidies or financial incentives, through mass purchases of domestic PV systems for interested customers. The PV systems will be selected by PPC to suit the specific load characteristics of the given residential area and will be offered to its customers at attractive low prices (due to mass-purchase discounts). Customers joining the programme through their electricity bills, in a number of equal instalments, will repay the system cost to PPC.

As far as tax incentives for corporation investments in RES are concerned, we note that such incentives are actually provided as alternative choices to capital subsidies in the National Development Law 2601/98. According to the law, investments and equipment-leasing programmes by corporations in RESe, can receive one (but not both) of the following subsidy packages:

(i)	Capital subsidy:	40% of the total investment cost
	Interest-rate subsidy:	40% of the interest paid on loans related to the RES investment
	Leasing subsidy:	40%
(ii)	Tax deduction:	100% of the total investment cost
	Interest-rate subsidy:	40% of the interest paid on loans related to the RES investment

The first subsidy package has already been discussed. The second subsidy package, for which a corporation may opt instead of the first one, contains two components of State financial support to RES investments: a 40% interest-rate subsidy and a tax deduction equalling 100% of the total investment cost (or equipment-leasing cost). This last form of financial support regards the exemption of the corporation from payment of income tax on the non-distributed net profits of the first decade following the materialization of the RES investment, by creating an untaxed (tax-exempt) reserve, equal in amount to the total RES investment cost. The 100% tax deduction is normally made from the profits of the particular tax year in which the RES investment is made. If there are insufficient or no profits in that year to cover the tax deduction, this deduction is made from the profits of subsequent tax years (and up to the tenth year), until the total RES investment cost is fully covered.

3. Existing market segments of the PV market

Trying to classify the current PV market worldwide we could distinguish some special segments [2,11] such as:

- the traditional market
- the off-grid market
- the urban grid-connected market
- the centralized utility market

3.1. The traditional market

This market segment, which includes applications for communications, water pumping, remote power and government demonstration projects, has an average annual growth of 15% over the past 20 years, regardless of the PV installation cost. This market segment is therefore obviously not price sensitive. Factors other than price, such as marketing and distribution, are much more important. Some companies in the past have not became conscious of this and have lowered their prices in order to create rapid market expansion and enlarge their market share. However, instead of achieving faster growth, they frequently made tremendous losses and most of them went out of business, doing a great disservice to the PV business. The traditional market needs to be seen as a cash market. It needs no subsidies, yet the availability of credit could substantially increase the size of the market.

3.2. The off-grid market

This market segment is not primarily price sensitive either, and its expansion depends on the available credit, rather than on prices or on the interest rates charged on loans. The off-grid market could experience explosive growth if credit for customers was available.

The expansion of the traditional and off-grid markets is strongly dependent on the PV global scale marketing and distribution. The development of a conventional distribution system started about 15 years ago. Up to then PV manufacturers had to open their own offices in most areas of the world to procure business. Today, a broad global PV industrial infrastructure exists and solar cells and panels are being manufactured as commodities. A great number of specialized companies have developed during this period specialized in components, system design, installations or building integration; a large number of these also became specialized installers, representatives, dealers, etc.

The PV marketing and distribution, like those of any other product—automobiles, electrical appliances or clothing—can only be effective and expand if the proper market development financing is available.

3.3. The urban grid-connected market

This market can be separated into two segments: *building facades* and *rooftop systems*.

Aesthetics and utility, rather than price, are usually the primary issues in the selection of materials for building facades. Since some of the companies specializing in this area realized this issue, it has become one of the fastest growing areas of the PV business. The problem is to obtain the proper mortgage and insurance facilities, not only for the buildings, but also for transportation and installation. Subsidies could certainly play a major role in the expansion of this market.

PV urban rooftop systems have become a fast-growing market, which exists as a result of subsidies, government regulations or people's interest in 'green' energy. In this case—in the same way as for the building-facade market—the availability of subsidies and financing is more important than pricing.

3.4. The centralized utility market

Unlike the previous three market segments, the central utility market is price sensitive and therefore, while the other segments can increase on the basis of current technologies, it is believed that the centralized utility market will not do so. It will only be viable when a new, very large-scale PV production technology emerges, guaranteeing a much lower price for PV. As soon as these reasonable prices will be achieved, the central utilities will be activated to finance new PV power plants.

4. Methodology of the market analysis

The realization of the analysis is based on an extensive research through questionnaires in combination with the use of data from other available sources.

All known data sources were used, such as: CRES unpublished data, proceedings from EU and international conferences, all major Greek market actors, local/regional agencies, accumulative experience from the PV marketing group, ministries, etc.

The market research by questionnaire aimed to identify the PV technologies potential in the Greek market and the existing barriers for their wide dissemination. The objective goal was the justification of the current limited number of such applications and the potential recommendations for a viable market strategy.

Through the questionnaire, the technical group contacted about 60 major market actors in Greece. They belong to the following categories:

- public bodies
- PV manufacturer suppliers
- main users
- others

The aim was to collect information about regions with great potentiality for PV applications and mark out the market segments that will be of great interest for future PV penetration.

Based on CRES' experience in Greece, Table 3 represents the most common PV applications. To cover the needs of the current market survey the following market segments were considered:

- electrification of remote villages and houses
- electrification of grid connected houses/settlements
- telecommunication transceivers, radio, TV
- public lighting
- pumping
- desalination
- educational kits
- marine signaling

Table 3
Current market segments

Criteria	Description
PV system type	Grid connected systems Autonomous systems
End-user (application) type	Centralized, medium-to-large scale systems (for electrification of villages, islands, or connected to a large grid) Residential buildings (single houses, multi-store buildings, etc.) Commercial buildings (hotels, 'demo'/promotional systems, etc.) Electrification of small (possibly uninhabited) islands Tourist sector (small hotels, archeological sites, cantinas, etc.) Ecological applications Special applications (lighthouses, desalination, telecommunications, school kits)
Geographical region	Mainland Islands (big, small)
Ownership/decision making/ market control regime	Public Private
User's (or opinion leader's) previous PV experience	Already aware of the PV user Not aware of PVs
% coverage of user's energy needs	Full (autonomous systems) Partial (e.g. small hotels in electrified islands) Low (PV system serves mainly for demonstration or image purposes, for example PVs in large commercial buildings)

The recipients of the questionnaire were:

- local services of Public Power Corporation (PPC) and Greek Telecommunication Organization (HTO)
- Marine Signaling Authority of Greek Navy
- responsibles of courthouses
- agencies of local administration
- PV suppliers
- main users
- other market actors

5. Questionnaire analysis

5.1. The correspondence

The correspondence in the questionnaire of the market research was satisfactory. In order to be more specific, we can allocate the response on three criteria:

- the contacted market actors (answers 36%, refusals 41% due to various reasons, no PV activity 23%)
- the active market actors: (answers 46.5%, refusals 53.5%)
- the total installed power in Greece (answers 77%, refusals 23%)

5.2. The current status

The PV market has expanded rapidly, especially in the recent years [6]. On the contrary to the weak first steps, PV applications have been remarkably accepted. This can be easily explained, if we take into account the high insolation during the year as well as the difficulties for the islands or some isolated areas to connect with the grid.

The current situation appears an unbalanced distribution (Fig. 1). The existence of company-leaders monopolizes the under-developed market, which consists of various SMEs.

The total installed power is about 1785 kW (2002), which indicates a strong change with reference to the 634 kW of 1998 (Table 4, Fig. 2).

5.3. PV categories

Fig. 3 represents the basic segments of the Greek PV market and their position in market in 2002.

5.3.1. Grid connected

This segment represents about 51% of the total installed power.

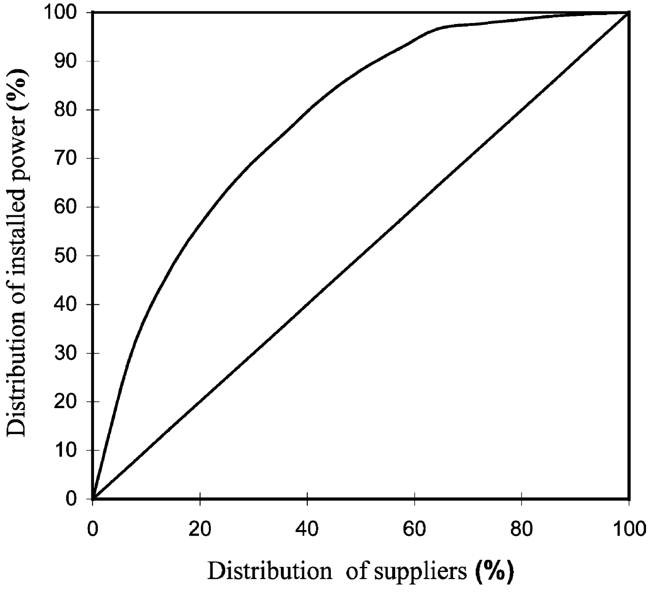


Fig. 1. Lorenz curve.

5.3.2. Autonomous applications

This segment is consisted of isolated houses, mobile homes, farming houses, etc. Their installed power is about 533 kW, which represents the 30% of the total installed.

5.3.3. Autonomous agricultural applications

The installed power of such applications is about 142 kW, which represents the 8% of the total installed.

Table 4
Market shares of the PV sales in Greece

	CRES' survey 1998	CRES' survey 1998 kWp	CRES' estimations, 2002 kWp
Autonomous houses	45.03	286	533
Grid connected	24.15	154	904
Autonomus rural applications	12.60	80	142
Telecommunications/repeaters	8.01	51	91
External lighting	1.93	12	22
Other applications	8.28	53	93
	100	636	1785

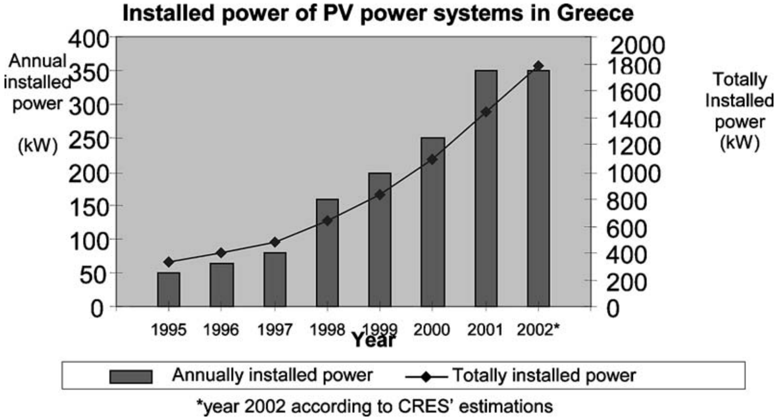


Fig. 2. Installed PV power in Greece.

5.3.4. Telecommunications-repeaters

On this segment the HTO is the leader. In recent years, radio/TV stations and mobile-phone companies have increased their activity. The installed power of 142 kW represents the 5% of total installed.

5.3.5. External lighting

This category represents only 1% of the total installed power.

5.3.6. Other applications

The lighthouses of the Greek Navy are the leaders on this category. Uses for navigation, training, research and demonstration are coming next. The installed power of 93 kW represents the 5% of total installed.

6. PV electricity market segmentation

Until 1998 most of the installed PV systems were stand-alone. During the last years the market has changed, since now most of them are *grid-connected*. In 1994

Table 5
Operational programme for energy, (CSF II, 1994–1999) RES funded projects

RE technology	Number of projects	Electrical capacity (MW_e)	Thermal capacity (MW_{th})	Total budget (M€)	Public funding (M€)
Wind	17	125.1		131.2	52.5
Biomass	9	20.4	94	47.7	22.5
Small hydro	11	14.3		21.7	9.7
Photovoltaic	15	0.9		7.0	4.8
Active solar	25		8	5.1	2.5
Passive solar	1			0.3	0.1
Total	78	160.7	102	213.0	92.1

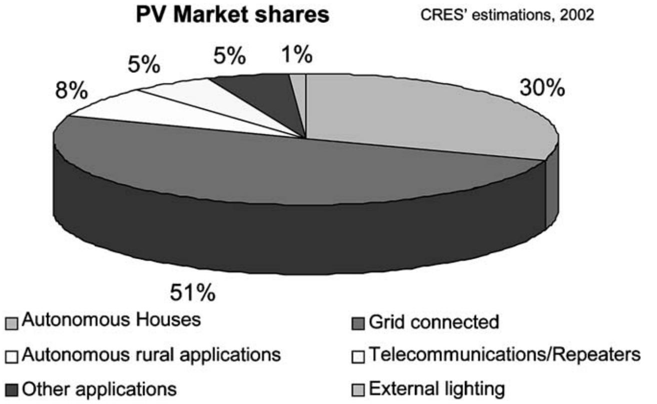


Fig. 3. Allocation of the PV installed power in Greece.

only 20% of the installed systems was grid-connected, while in 2001 this was more than 50%. Most of them are applications in the building sector [1].

6.1. Autonomous houses/settlements

There is a range of such PV systems in terms of installed peak power. At this time many of those systems are made of a few panels (<500 Wp) and support basic needs such as lighting, small appliances and refrigerators.

Most of these systems are providing DC service, usually the small ones and some of them AC. The market segment above 500 Wp is quite small, at this time, due to PV system cost in relation to the buying power of the potential users [12].

In the population census conducted by the National Statistical Service in 1991, electrified houses were considered as those having an electricity source, i.e. utility grid, diesel generator, PV, wind generator, etc. Scattered non-electrified houses over the whole country that were seasonally or permanently occupied, isolated, or built in areas where building is not permitted are included.

Most of the non-electrified houses are located in rural areas. Those houses along with most of those located in semi-urban areas can be considered as the actual potential market of PV. A number of non-electrified houses are not scattered throughout the country but belong to small villages (settlements). These houses are occupied seasonally or permanently and are located in areas far away from the national electricity grid.

Taking into account the trend in electrifying non-grid-connected houses during the decade 1981–1991 and the results obtained from the analysis concerning the electrification of remote settlements, it can be concluded that the number of non-grid-connected houses since 1991 should have reduced by 20%. This means, that today there are 115,000 non-grid connected houses (permanently inhabited, seasonally inhabited and abandoned houses).

On the basis of the 1991 census data, the total number of inhabited non-electrified houses is 24,824, i.e. 0.79% of the total number of inhabited houses in Greece, while the number of non-electrified houses is 143,174 i.e. 3% of the total number of houses. This last number includes permanently and seasonally inhabited houses, as well as weekend and abandoned houses.

Most of the non-electrified houses are located in rural areas. Those houses along with most of those located in semi-urban areas can be considered as the actual PV market potential.

A number of non-electrified houses are not scattered throughout the country but belong to settlements. These houses are occupied seasonally or permanently and are located in areas far away from the national electricity grid in the last 27 years; the number of such settlements has been reduced from 1400 in 1981, to 873 in 1991 and recently (end of 1995) to 607; 373 of those settlements are inhabited by 8651 people (1991 census). One hundred of them have been already included in the future electrification program but most of them will remain without electricity because access by heavy-duty vehicles is not possible. The total estimated number of houses in those settlements is 14,000 and among those the inhabited are 2800.

Most of the non-grid-connected houses, permanently inhabited, are located in remote mountainous regions where the access is very difficult due to the lack of accessible roads. They are old houses, made of stones, bricks or concrete blocks and covered by tiles, flagstones, metal sheets or a concrete terrace. Most of them are south facing, non-shaded and have available roof area for a PV system or enough free space for ground installation. Their proprietors are poor people, mainly dealing with stock farming or agriculture, have a poor knowledge of PV systems and cannot afford a PV system. Conventional electric appliances are used when a diesel generator is available. DC appliances are used in combination with PV systems and batteries.

The most important electricity needs to be satisfied are: lighting, refrigeration and TV operating in DC mode. The theoretical potential for the application of PV in non-grid-connected houses in Greece is estimated to be about 32 MWp, assuming an average occupation of three inhabitants per house and 200 Wp per inhabitant (the abandoned houses are not included).

Although the theoretical potential is considerably high, the actual potential is lower considering that a significant number of non-grid-connected houses may be electrified after legalization and that most of the owners cannot afford the cost of a PV system without financial support.

6.2. Autonomous small/rocky islands with development potential

In this category of islands we include all those islands that have about 500 inhabitants or less, or are uninhabited for the winter season. There are at least 50 such islands that are inhabited and several hundreds that are not inhabited and have the potential for development in an environmentally friendly way. The main activities that may be undertaken in these islands are ecotourism, agriculture and fishing. The development of such islands using environmentally friendly technologies is

very important for the improvement of the inhabitants' living conditions. The creation of a more stable economic environment will keep the inhabitants in their islands reversing the alarming abandoning trend [12].

An estimation of the permanent population in this category is 5000 people. During the summer months the population in these islands may be 2–3 times higher than the permanent population. The power service of the local grid is usually poor and power cuts are frequent. PV systems may improve the power service, increase the income of the islanders and stabilize their population. Assuming an average introduction of 200 Wp per permanent inhabitant, there is a potential PV market of 1 MWp. If the islanders have the scope to provide services to the summer tourists, then the potentially installed capacity may be a few times larger.

6.3. Telecommunications

This is a market that is already economically viable around the world. In Greece, there are a few applications by the Greek telecommunication companies (Greek Telecommunication Organization, Panafon, Telestet). In most of these sites, where the telecommunication companies are planning to install relay stations, PV systems compete with the cost of electrification by grid line extension, except for the sites that are too far from grid lines or cannot be reached by trucks and where the cost of opening new roads is too high [5].

6.4. Public lighting of roads, signaling, billboards, powering small devices etc.

This market is practically non-existent in Greece, although in other countries such as USA, Germany and Egypt there is a number of companies that are active in this field. Some bus stops had small PV applications.

6.5. Exterior road and park lighting and signaling

The viability of such systems can be justified by:

- the possible extension of the grid by digging out several meters,
- the remediation of the grounds to their previous condition

The associated cost of the above actions may be too high with respect to an autonomous PV lighting/signaling system that could later be moved again with minimum cost.

The estimated market potential can be significant, if PV lighting is examined as one of the possible solutions by municipalities, whenever the lighting of roads, parks, squares, boat marinas, docks etc. is being planned. PV lighting will not always be the most appropriate solution, due to cost and to the possible combination of high power lighting applications and limited area availability of PV surface on a pole. A PV system for street lighting, with two 50–55 Wp modules, a 18–36 W low pressure sodium or fluorescent lamp and the associated electronics, battery, pole etc., cost from 2–3 k€ [2].

6.6. Advertising board lighting

This is a market with considerable potential. Any given site that has potential for promotion of products and does not have reasonably easy access to the grid can be a moneymaking location for the advertising companies when lit by a PV system. Such PV systems could have a significant potential if the advertising companies become aware of such a possibility.

6.7. Small devices

PV could power other possible devices such as: parking ticket issuing machines, lighting of public card-phones etc.

If for example, a telecommunication company decides to light 10,000 card-phones by PV, with an installed power of 30 Wp per card-phone, then the total PV power would be 300 kWp. The PV powered parking ticket machine introduction is a possible application that frees the local authorities from the electric grid and all the necessary groundwork to power the parking ticket machines.

The economic viability of many of the above PV applications has to be determined on a case-by-case basis.

7. The potential

The Greek PV market seems to be in an embryonic phase with some applications supporting the small number of companies in the sector contrary to the excellent solar conditions, which favor the PV applications. PV potential could cover 25–30% of domestic needs.

Furthermore, the use of PV for a noise barrier in high-speed roads and railroads could represent a potential of 6.2 MW for new roads and 13.4 MW for railroads [9].

Almost 40 companies are involved in the Greek sector (PV providers, studies, installations, etc). The bigger part installs annually only 20–250 kW [1].

The Greek PV market has grown rapidly during recent years supported by the existing European, national and regional programmes (OPC, OPE, THERMIE, VALOREN, ALTENER, OPRT, etc.) reinforcing the promotion of PV applications. These programmes provide support and information for the dissemination of know-how.

Similarly, the establishment of a favorable institutional and legislative framework (Energy Law 2244/94, the Development Law 2601/98, etc.) has created very positive conditions for PV technology and investments.

The houses/settlements in isolated areas (islands and/or continental) are presented as the most attractive application for the users (29%). Followed by the transceivers (19%), the agricultural applications (16%), the houses connected with the grid (14%) and the navigation applications (13%).

The above demand arises from the needs and the motives of users, which were recorded in the market analysis, are:

- electrification for isolated-faraway areas: 48%
- ecological sensitization: 20%
- electrification-connection with grid: 12%
- independence from PPC (power failure, taxes, etc.): 8%
- energy saving: 8%
- attractive financing: 4%

Additionally, the appearance of new PV manufacturers and a general mobility on PV technologies (national and European Programmes, institutions, universities, groups of scientists, etc.) depict a market ready for further expansion.

The market actors' forecasts are reliable, when 67% of them refer to an increase of between 10 and 40% per year (Fig. 4). This estimation is compatible with those of the world market growth (average annual market growth 40%).

On the other hand, there is an optimistic aspect (25%) which aims at a yearly increase of >40%. Finally, only 8% of the surveyed market actors believe that the dynamic of this market is too poor.

The response in the survey was very satisfactory (46% of the current active market actors), which means a great interest for cooperation in the sector. Actually, PV market research plays the role of pioneer for the Greek market, and we are positive that a focused market survey through each PV application would be even better (as a follow-up).

The first industrial facility producing PV in Greece (a-Si double junction 4th generation, production capacity 5 MW per year, with prospect to upgrade to 10 MW in the technology of CIGS-Copper indium gallium diselenide) has been constructed in Northern Greece by the HELIODOMI SA in cooperation with the American company EPV. The first PV production will start in early 2004 with a

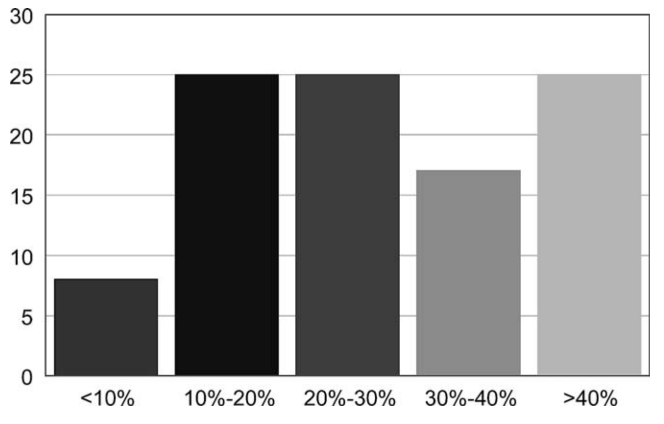


Fig. 4. Forecasts on sales (%/yr).

production cost of 2 €/W. This low production cost is estimated to lower the consumer prices. The PV systems will have a nominal power of 10–160 Wp. In the rooftop of the industrial plant a 400 kW grid will be installed and connected.

The procurement and installation cost of PV is 6000–10,500 €/kWp (typical price 9000 €/kWp) for grid connected and, on average, 11,000 €/kWp for autonomous. on average, during the last 4–5 years, there was a real reduction of the procurement cost by 15%.

8. The barriers

Generous public subsidies (grants, tax exemptions), available to RES investments through the National Development Law 2601/98 and Measure 2.1 of the National OPC/CSF III, coupled with satisfactory (and fixed) buy-back rates for RES electricity sold to the grid, have led in recent years to a blossoming of investment interest for RES in Greece. However, despite this particularly strong interest of Greek and foreign investors, that has resulted in hundreds of applications for commercial RES projects all over Greece, and has led to the issuing of more than 2700 MW_{el} of RESe generation licenses by the Regulatory Authority for Energy [10], the pace of materialization of the corresponding investment projects has been slow. The most important obstacles are outlined below [14].

8.1. RES licensing procedures

Undoubtedly, the complex licensing procedures for RESe projects, set by various Ministerial and Joint Ministerial Decrees constitute the single, most difficult obstacle today in the effective materialization of commercial-scale RES investments in Greece. These procedures involve a multitude of central, regional, prefectural and local authorities (departments, committees, councils, agencies, etc.), interwoven in a lengthy, bureaucratic and, at times, confusing licensing process, that invariably takes 1.5–2 years to complete. Any single RES installation license requires the official expression of (positive) opinion of more than 35 public-sector entities, at the central, regional, prefectural and local level, and needs to be checked, in terms of conformity, with four National Laws and seven Ministerial Decrees (Fig. 5).

The transfer, in late 1998 (Law 2647/98), of most RES licensing jurisdictions and competences, from the central to the regional and prefectural authorities, has compounded the already difficult situation, creating more problems than those it was supposed to solve. This is due to the structural and organizational weaknesses that still plague regional and local administrations in Greece, such as severe budgetary constraints, lack of specialized knowledge, RES-related experience and trained personnel, parochial ideas and conflicts, etc.

Revoking these administrative obstacles, Law 2941/01 and at the same time, Law 2773/99 are currently under revision in order to compensate for the slackness of the liberalization process of the electricity market mostly attributed to the dominant position held by PPC SA and also to reflect the modifications portended by

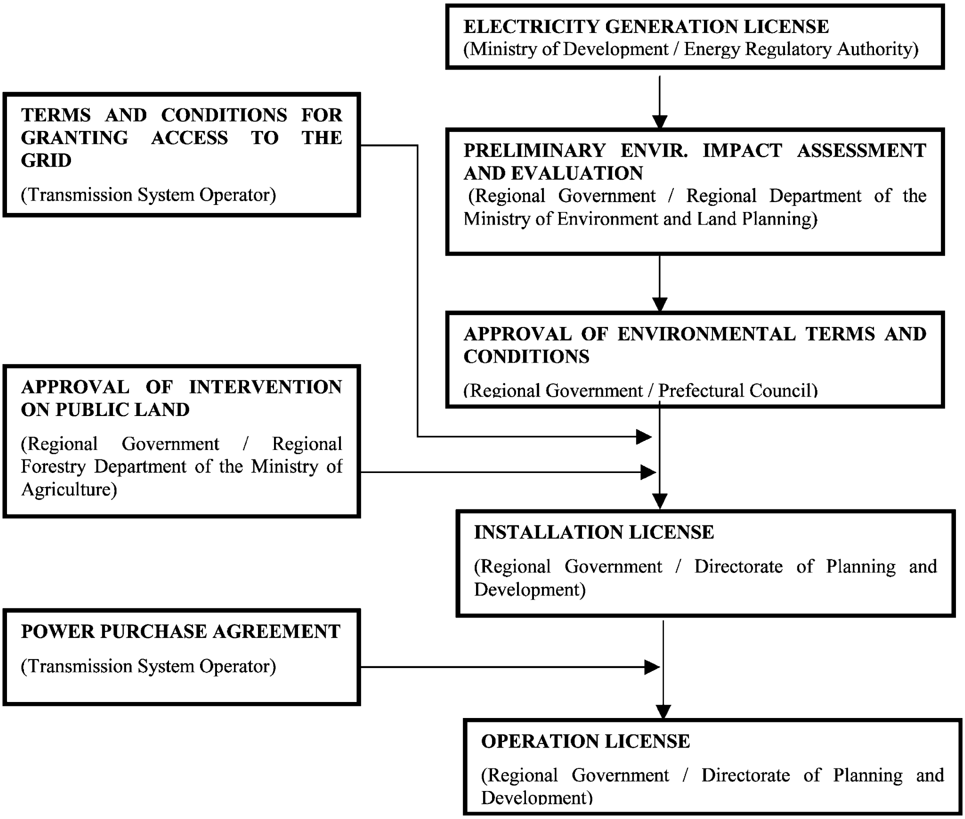


Fig. 5. RES licensing procedures and jurisdictions.

the ongoing revision of Directive 96/92/EC. At the regulatory level, a joint ministerial decision has been signed (JMD 1726 of 2003) in order to adjust the overall licensing procedure of RES projects to the environmental consent process introduced with the new Law 3010/02. Among the regulations introduced, it is worth mentioning the fixing of shortened time limits. Should no action be taken within these limits, the authority managing the licensing procedure is entitled to consider as positive the lacking interim approvals or opinions of other services and bodies and thus to urge forward to completion of the licensing process. This expedient fully reflects the requirements of article 6 of Directive 2001/77/EC [8].

8.2. Limited capacity of the power transmission grid

As of 2002, new RES capacity can no longer be connected to the existing grid (due to its capacity saturation). The upgrading of the power transmission grid has to face a crucial problem: their long period of materialization, which exceeds 5–6

years, due to difficulties (public reaction, etc.) in land expropriation and construction of high-voltage power lines through environmentally sensitive areas.

8.3. Public attitudes

Although opinion polls in Greece invariably show a very positive attitude and support of the general public towards RES, this attitude seems to have a strong NIMBY ('Not In My Back Yard') component.

Reasons offered by local entities resisting RESe development in their areas include visual intrusion, noise, land devaluation, etc., but also perceived health problems to people and animals, negative impact on local tourism, deforestation, little or no benefit to the local economy (employment/added value), etc.

9. Conclusions and recommendations

Following the successful implementation of the OPE, the National OPC initiated in 2000 by the Ministry of Development is expected to have a significant impact on the development of RESe within the next few years [8].

The PV market will continue to expand rapidly in the future in its major market segments. The main obstacle to the explosive expansion of the PV market is neither technology nor price. It is focused on *financing* and *advertising*.

The need to develop financing methods, distribution mechanisms and infrastructure was realized a few years ago and the complex problems have been discussed in various studies and meetings. The result is that some progress is being achieved. However, the need for *advertising*, *training*, *promotion*, and *education* is only now being recognized. The lack of these basic elements is a formidable obstacle to the future of PV, and the PV community must focus on this matter urgently.

In addition to the previous barriers, the PV market analysis [11,12,13], various 1998, indicates the major parameters for the further PV market penetration in Greece:

- assured quality
- advertising, training, promotion, and education
- financing of PV products and systems

9.1. Quality of products and systems

The issue of quality of PV products and systems is crucial. Many PV component and system failures have been reported, especially in off-grid rural electrification projects. This inconsistency of quality thus became an important issue, affecting not only the financing, but also the future of the entire PV business. The PV industry and its major customers, who established the PV Global Approval Programme, realized this issue.

9.1.1. Public awareness and creating markets

There is a great need for PV advertising, as well as for training, promotion and education. In the oil crisis era of the 1970s, when the terrestrial PV business began, media attention, focused on the then minuscule PV business, was significant and helped the establishment of PV in many market segments. However, the media attention stopped in the 1980s and today the public is not aware of the extent to which PV is already being utilized. The general belief is that PV is for the future. It is not widely known that without PV, there would be no global communication, no global email, Internet, TV, telephone, fax, because all the satellites used for these functions are 100% powered by PV.

There are no exact figures on how much the entire PV industry is spending on advertising, but as a first estimation the relevant budget is much less than 0.5% of the total revenues.

If it was clear that the PV market is not primarily price sensitive, and that a large market share could be obtained by advertising rather than by lowering prices, the PV industry would now be in a better condition. The PV industry today is not in the position to invest the necessary funds in advertising and in public awareness campaigns. Yet this is a crucial issue for the future of the PV business and should be addressed urgently. The enterprising spirit of the PV industry, and other interested parties, must mobilize resources for advertising, promotion and education/training. A discussion on the issue must take place as well as solutions have to be found.

9.1.2. Finance and future

Financing of PV installations is crucial for their future. The urban grid-connected and, to some extent, the off-grid markets are also dependent on subsidies. The merits and demerits of subsidies can be debated endlessly. If they apply for the long term, subsidies are necessary and beneficial. However, short-term subsidies would be detrimental for the PV business.

It is urgent to develop financing mechanisms for PV systems. The lack of financing available for customers is an enormous handicap to the development of the PV business. Much PV business in the developed countries and two billion potential customers in the developing countries need financing. This means that PV financing is a very complicated issue. Several interesting approaches are being tried and planned and various meetings have focused on this very complicated issue in an attempt to find solutions.

It is also essential that the effective consortia are set up to face these opportunities [3]. Experience indicates that the better the partners' fit, comprising social fit (trust and commitment), resource fit (competence and complementarity) and goal fit (goal clarity and compatibility), the better the projects will progress and succeed.

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